RDECOM

CERDEC
US ARMY– RDECOM

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Hydrogen as a Battery Extender

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The Competition

- Bullet-proof reliability (and even bullet-resistant in a few cases)
- Standard sizes; multiple applications
- Pulse Discharge up to ~ 100A
- Operation at 30,000 feet; underwater; -20 to -30°C
- Refuel (recharge) from vehicle

The Competition Continued…

- Battery technology not holding still
- LiCFx near-term (>400 Whr/kg)
- Improved Li-ion and Li-polymer near-term (~200 Whr/kg; driven by hybrid automotive applications and BIG funding)
- Improved zinc-air near term; Li-air long term (>1000 Whr/kg?)

So Why Fuel Cells?

We need to buy less stuff, and move less stuff around

HOWEVER…

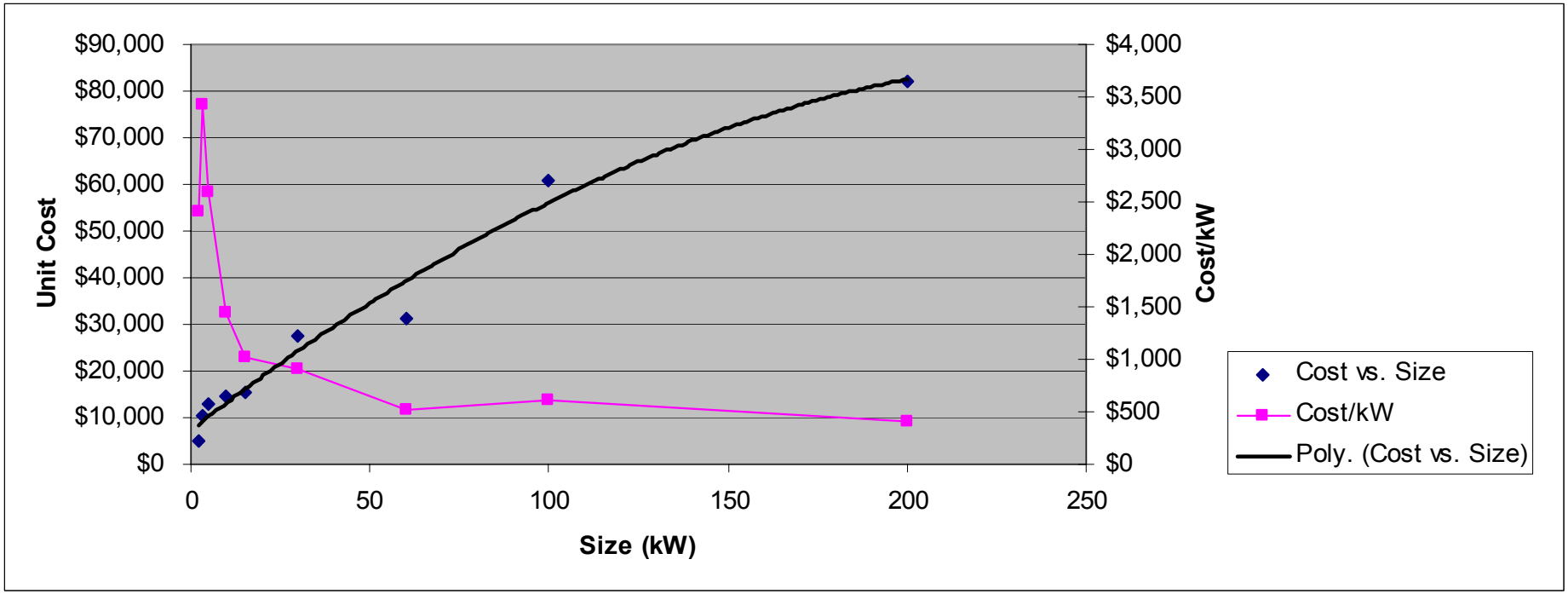
We need to run our gizmos longer, and there are more gizmos coming…

Operating Cost Vs Purchase Cost

- 80% of generator life cycle cost is fuel

- 1 Watt of Soldier power is roughly $1M in battery cost over the life of the device

Purchase Cost of MIL-STD Power

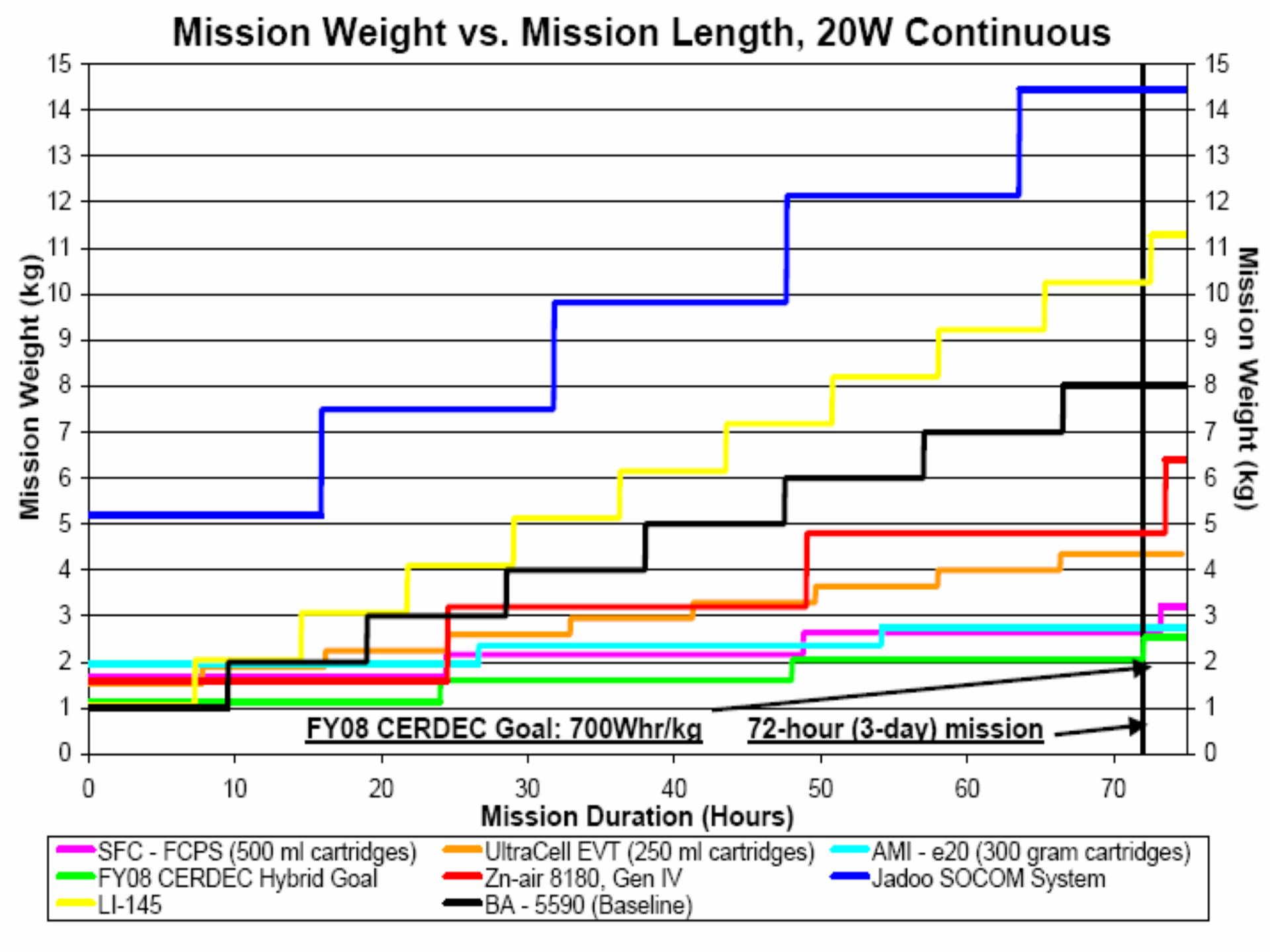


Logistics!! ...

Energy / Weight

Energy / Volume

Lots of batteries =
Lots of trucks =
Lots of fuel,
Lots of targets


Mission Weight vs. Mission Length, 20W Continuous
Mission Weight (kg)
Mission Duration (Hours)
0
10
20
30
40
50
60
70
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
FY08 CERDEC Goal: 700Whr/kg
72-hour (3-day) mission
SFC - FCPS (500 ml cartridges)
UltraCell EVT (250 ml cartridges)
AMI - e20 (300 gram cartridges)
FY08 CERDEC Hybrid Goal
Zn-air 8180, Gen IV
Jadoo SOCOM System
LI-145
BA - 5590 (Baseline)

H2 for Field Use

- Pressurized and Flammable
- Inefficiency of refill (cool or compress); added infrastructure
- Weight and volume not attractive compared to liquid fuels
- Possibly will see H2 production from waste streams and consumption on-site for large complexes

So How Do We Get There??

Desired: Simplicity/Reliability of PEM Stack with Energy Density of Liquid Fuel; Inert Fuel; Cheap System

- Options:
  - Chemical Hydrides
  - Fuel Reforming
  - Direct Fuel Use

Chemical Hydrides

- Sodium Borohydride
- Ammonia Borane
- Lithium-Aluminum Hydrides

- Water recovery and complex control systems (if required) adds system complexity and negates PEM simplicity
- Storage/Safety Issues
- Response to load variation

Fuel Reforming

- Methanol
  - High temperature process aids heat rejection
  - Steam Reforming has water penalty
  - toxic
- Propane/Butane
  - Widely available, already packaged, cheap, high energy fuel
  - Gets back to pressurized/flammable, but maybe not worse than methanol…
  - Requires hi-temp stack

Direct Fuel

- Direct Methanol
  - Big commercial push
  - High energy fuel
  - Complex system (for “active” technologies)
- Direct Borohydride
  - Good potential
  - Immature technology

Direct Methanol Fuel Cell

- EFOY (Smart Fuel Cell) 20W system
- Dimensions: 9.75” x 2.31” x 3.06”
- System Dry weight: 1.18 kg
- Fuel cartridge: 500 ml / 0.47 kg
- 24 hr mission weight: 1.6 kg
- 72 hr mission weight: 2.6 kg
- Efficiency: 22.4%
- Fuel Cartridge Duration: 24 hours
- Fuel is 100% methanol at low temp; water/methanol mix at high temp >40ºC
- 72 hour mission energy density: 554 W-hr/kg

Reformed Methanol Fuel Cell

Ultracell Corporation

25W Reformed Methanol Fuel Cell

Dimensions: 9.3'' X 5.38'' X 1.8''

System Dry Weight: 1.2 kg

Fuel Cartridge Weight: .325-.350 kg

24 hr mission weight : 2.25 kg
72 hr mission weight : 4.23 kg

Efficiency: 23.8% @ 20 watts
Fuel Cartridge Duration: 9 hours

Fuel is 67/33% methanol/water mix

72 hr mission energy density: 360 W-hours/kg

Summary

- Fuel Cells will be battery alternatives and hybrids, NOT battery replacements
- Hydrogen is not a viable option
- “Winning” fuel cell technology hasn’t yet shown itself
- System design/balance of plant/reliability still key issues
- Soldier –wearable fueled power sources are a tough challenge!